



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁵ :

B41J 2/175

A1

(11) International Publication Number:

WO 92/18335

(43) International Publication Date:

29 October 1992 (29.10.92)

(21) International Application Number: PCT/US92/03074

(22) International Filing Date: 15 April 1992 (15.04.92)

(30) Priority data:

3/85295

17 April 1991 (17.04.91)

JP

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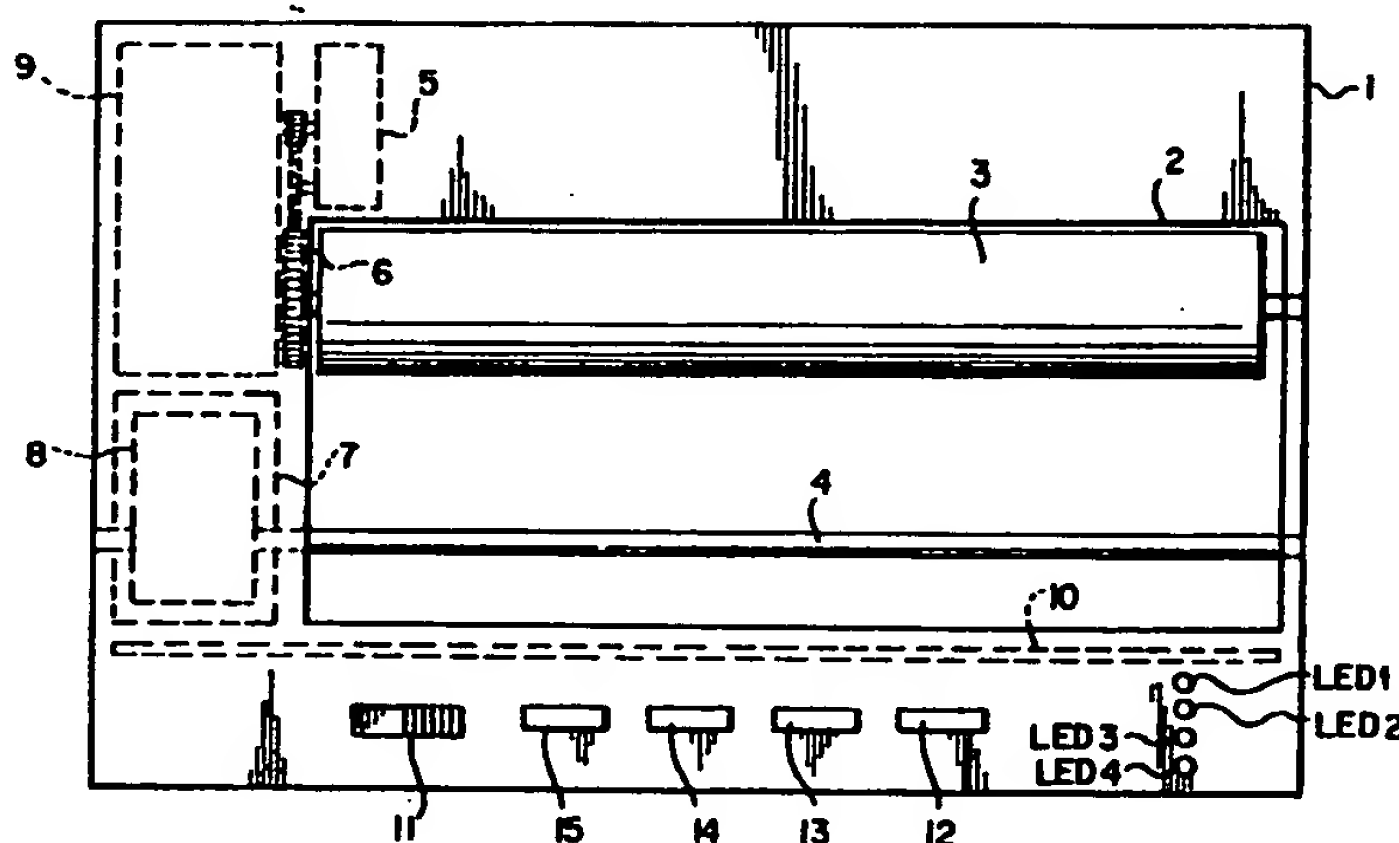
(81) Designated States: AT (European patent), BE (European patent), CH (European patent), DE (European patent), DK (European patent), ES (European patent), FR (European patent), GB (European patent), GR (European patent), IT (European patent), LU (European patent), MC (European patent), NL (European patent), SE (European patent), US.

Published

With international search report.

Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: INK RESIDUAL QUANTITY SENSOR OF INK JET PRINTER



(57) Abstract

At the time of printing, the number of dots actually printed is stored in printed dot number storage means (28). At each operation of priming means (9), quantity of suctioned ink is cumulatively stored as a number of printed dots in printed dot number storage means (28) by means of storage control means (30). When it is desired to check residual quantity, ink residue detection means (31) computes it based on the ratio of a number of printable dots corresponding to the full volume capacity of ink cartridge (8) and the number of printed dots stored in printed dot number storage means (28). According to the present invention, an ink jet printer, which has a head having a head nozzle to eject ink for printing, ink cartridge (8) containing ink and priming means (9) to suction ink while applying pressure to the head nozzle, is provided with an ink residual quantity sensor characteristically having printable dot number storage means (27) to store a number of printable dots corresponding to the full volume capacity of said ink cartridge (8), printed dot number storage means (28) to store a number of dots actually printed by the head, storage control means (30) to cause quantity of the ink which has been suctioned to be cumulatively stored as a number of printed dots in printed dot number storage means (28) for each action of priming means (9), and ink residue detection means (31) which computes the residual quantity of ink based on said numbers of printable dots and printed dots.

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INK RESIDUAL QUANTITY SENSOR OF INK JET PRINTER**BACKGROUND OF THE INVENTION****FIELD OF THE INVENTION**

The present invention relates to apparatus for sensing and displaying the
5 amount of ink remaining in an ink cartridge of the type used in a conventional ink
jet printer.

DESCRIPTION OF THE PRIOR ART

Conventional ink jet printers operate to print information on paper by
selectively projecting drops of liquid ink supplied by an ink cartridge. Some of
10 these printers are able to detect depletion of ink in order to prevent running out of
ink during the process of printing. For example, detection of ink depletion has
been heretofore done by means of a pair of electrodes so placed inside the ink
cartridge that current between the electrodes is terminated when the ink level
comes down below the electrodes. Another scheme is to place a magnetic float on
15 the surface of the ink so that when the float comes down as the ink is depleted, it
is detected by a magnetic sensor attached to the side of the ink tank, thereby
making it possible to detect a shortage of ink.

As described above, some conventional devices detect depletion of ink
directly by the lowering of the ink level. Therefore, it is necessary to provide a
20 cartridge with electrodes, a magnet float or other similar parts, which makes an
ink cartridge costly. Further, with the above schemes, it is not possible to detect
the residual quantity of ink, but only to detect a shortage of ink just before the ink
contained in the ink cartridge runs out.

U.S. Patent No. 4,714,937 to G.T Kaplinsky briefly mentions a concept
25 of determining the level of ink in an ink supply by counting the number of nozzle
firings. But this approach does not take into account the considerable volume of

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ink that may be sucked through the printhead during an ink-priming operation to remove ink clogs and the like from the printing nozzle(s).

SUMMARY OF THE INVENTION

Regarding the above problems, the present invention has as an objective
5 the provision of an ink residual quantity sensor for an ink jet printer capable of accurate detection of the residual quantity of ink in an ink cartridge without increasing cost of the ink cartridge.

According to the present invention, during the printing operation of an ink-jet printer, a number representing the number of dots actually printed by the
10 printhead is stored in a first storage device. With each action of an ink priming means which serves to suction a predetermined quantity of ink through the printing nozzle(s), a storage control device serves to add to the stored number of dots actually printed a number representing the number of dots that could have been printed by the suctioned quantity of ink. The residual quantity of ink in the
15 cartridge is determined by an ink residue detection means which compares (a) the sum of the number of dots actually printed and the number of dots which can be printed by the suctioned quantity of ink with (b) a number representing the number of dots which are printable by a full volume capacity of ink cartridge 8, such number of printable dots also being stored in a storage device. The result of
20 this comparison is displayed by a gauge or the like on the printer housing, or by printing a display representing the residual quantity of ink on a sheet of paper.

The invention and its advantages will be better understood from the ensuing detailed description of preferred embodiments, reference being made to the accompanying drawings.

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BRIEF DESCRIPTION OF THE PRIOR ART

Figure 1 is a top plan view of an ink jet printer.

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Figure 2 is a block diagram showing an embodiment of an ink residual quantity sensor of an ink jet printer according to the present invention.

Figure 3 is a flow chart illustrating various steps of a program for implementing the method of the invention.

5 Figure 4 is an explanatory drawing showing an example of display of residual quantity of ink.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

A preferred embodiment of the present invention is explained
10 hereunder, referring to the drawings.

Fig. 1 shows a top plan view of an ink jet printer. An opening 2 is formed in the upper surface of the printer housing 1, and a roller platen 3 and guide axis 4 are provided in parallel to each other within opening 2. Platen 3, which is rotatably supported, is rotated by the driving power of a stepping motor 5
15 through a plurality of gears 6. A carriage 7, which is moved laterally by the driving power of a stepping motor (not shown), is movably attached to guide axis 4. Replaceably attached to carriage 7 is an ink cartridge 8 which contains specified quantity of ink and is integrally provided with a printhead having a head nozzle to eject ink.

20 An ink priming means 9 is attached to one end of platen 3. In the same manner as disclosed in published Japanese Patent Application No. 275709/1990, priming means 9 has a precision pumping mechanism which enables it to precisely control the quantity of ink it suctions with a single pumping action. Such mechanism comprises a pump, a stepping motor to drive this pump and a cap
25 member having a tube connected to the suctioning end of the pump. When carriage 7 is positioned opposite or in front of the priming means 7, the cap covers the head nozzle in order to prevent drying up of ink on the nozzle, and a negative

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pressure is applied by the pump to the head nozzle in order to suction ink therefrom, thereby preventing the nozzle from clogging up. Further, this priming action is performed automatically when an ink cartridge is replaced, or after a predetermined amount of printing has been done (e.g. 50 pages of printing), or
5 whenever it is desired to do so., such as by depressing a switch 12.

A printed circuit board 10 having a control circuit, which is described later, is positioned as shown in the printer housing. The printer housing is also provided, on the upper surface thereof, with power switch 11 and a plurality of operation switches 12 through 15. Optionally, a set of light-emitting diodes LED1
10 - LED4 can be mounted atop the printer housing to display, for example, the residual amount of ink in a cartridge and/or different selected printing fonts.

Fig. 2 is a block diagram of the control circuit on the aforementioned printed circuit board. Numeral 21 denotes a control unit for inputting printing data. It controls the printing operation by controlling a head driving unit 22 which
15 drives the printhead, a carriage driving unit 23 which drives the stepping motor of carriage 7, and a paper feeder driving unit 24 which drives the stepping motor 5 of platen 3. Control unit 21 also performs ink priming by controlling a pump driving unit 25 which drives the stepping motor of the pump of priming means 9.

Connected to control unit 21 is a memory unit 26 having a first storage
20 means 27 for storing a number representing the total number of printable dots, which can be computed from the full volume capacity of ink cartridge 8, a second storage means 28 for storing a number representing the total number of dots actually printed by the printhead, as well as the number of drops that could have been printed by the ink suctioned through the print head during the priming
25 operation(s), and a counter 29 for counting a number of dots printed on a single line. Storage means 27 and 28 comprise nonvolatile memories.

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Control unit 21 comprises a suitably programmed microprocessor which enables it to function as (i) a storage control means 30 for causing, at each operation of priming means 9, the number of dots that could have been printed from a quantity of suctioned ink to be added to the number of actually printed dots stored in storage means 28; (ii) an ink residue detection means 31, which
5 computes the residual quantity of ink based on respective numbers of printable and actually printed dots stored in storage means 27 and 28, respectively; and (iii) a display output means 32 for causing the computed residual quantity of ink to be displayed.

10 The operation of the apparatus discussed above is explained hereunder, referring to Fig. 3. The explanation begins from the stage for replacing ink cartridge 8 with a new one (Step 4).

The change mode begins when power switch 11 is turned on with switch 12 held down (Step 5). Since carriage 7 is always positioned opposite the priming
15 means 9 except while printing, it is not generally possible to physically reach the ink cartridge 8 for the purpose of replacement. When the change mode has commenced, however, control unit 21 drives the stepping motor through carriage driving unit 33, thereby moving carriage 7 to the center of the printing range (Step 6) so that ink cartridge 8 can be replaced.

20 Then, the operator releases the mechanical lock which holds the cartridge on the carriage, replaces ink cartridge 8 with a new cartridge and sets the mechanical lock again (Step 7).

After changing the cartridge, when switch 12 is turned on (Step 8), control unit 21 clears the memory in printed dot number storage means 28 and
25 causes carriage 7 to be moved to a position opposite priming means 9 (Step 9). When carriage 7 has moved to this position, the cap member covers the head nozzle, and priming is performed under this condition (Step 10). Control unit 21

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drives the stepping motor of the pump through pump driving unit 25 and, using the action of the pump, applies negative pressure to the head nozzle to suction ink.

Since the quantity of suctioned ink can be represented as a number of printed dots, such number can be stored in storage means 28 by control unit 21
5 functioning as storage control means 30 (Step 11).

In the above description, the printer was set at the change mode at Step 5. In case ink cartridge 8 is not to be changed, however, by turning off power switch 11, carriage 7 can be moved to the priming position opposite priming means 9, thereby returning the printer to the stand-by mode (Steps 12 and 13).
10 The power is cut off thereafter.

Next, the function when printing is in progress is explained.

When paper has been set at platen 3 and a command to start printing is given, any counted value by counter 29 is cleared and one line of image information is printed (Step 14). Printing is done with ink ejected onto the paper
15 from the head nozzle, while carriage 7 is moving. At that time, the number of dots actually printed by the head is counted by counter 29.

When a line of printing has been completed, the number of printed dots counted by counter 29 is cumulatively stored in printed dot number storage means 28 (Step 15).

20 Printing is performed with Steps 14 and 15 being repeated as above.

When a number of printed pages has reached 50 in total (Step 16), carriage 7 is moved automatically to the front of priming means 9 (Step 17) to receive the priming action described above (Step 18).

The quantity of ink suctioned by the above priming action is converted
25 to a number of printed dots, and this number is stored in printed dot number storage means 28 by the storage control means 30 of control unit 21 (Step 19).

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If the current printing operation has not yet been completed, the printer is returned to Step 14, from which the process is resumed (Step 20).

Next, the explanation is given as to the procedure of checking the residual quantity of ink prior to printing.

- 5 The operator turns on power switch 11 while holding down switch 14 (Steps 1 and 2), thereby setting the printer at the test mode. Paper should be set on platen 3 beforehand.

Control unit 21 determines, using its function as ink residue detection means 31, the residual quantity of ink by comparing the number of printable dots
10 stored in printable dot number storage means 27 with the number of actually printed dots (which includes the dots that could have been printed by the suctioned ink), which was input in printed dot number storage means 28 in the manner described above. Then, using its function as display output means 32, control unit
21 causes the value of ink residual quantity to be displayed.

- 15 According to a particularly preferred embodiment of the present invention, the residual quantity of ink is printed on paper. As it is shown in Fig. 4, it is indicated as a bar graph whose length represents residual quantity of ink in relation to the length representing the full volume capacity (Step 3).

Therefore, residual quantity of ink can be easily confirmed by checking
20 the display of the residual ink quantity. Thus, it is possible to accurately estimate the time when ink cartridge 8 should be changed.

If it is found necessary to change ink cartridge 8, the operator should proceed to Step 5 to change the cartridge. In cases where replacement is not necessary, he may proceed to Step 14 to start printing.

- 25 As described above, ink cartridge 8 is not provided with special parts for detecting residual quantity of ink, and, therefore, its cost can be kept low. Further,

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detection of residual ink quantity can be conducted through software in a microcomputer incorporated in an ink jet printer.

Priming action can be actuated by a manual command by operating switch 12 when power switch 11 is at the "on" position.

5 The manner of displaying residual quantity of ink is not restricted to the aforementioned manner that calls for printing on paper; it may be indicated by means of a liquid crystal display or a lamp. Alternatively, the output of the residual ink detector can be used to energize one or more of the LED's (LED1-LED4), the more LED's energized, the greater the quantity of ink remaining in the
10 cartridge.

 According to the present invention, the number of dots actually printed is stored in a printed dot number storage means, and, whenever priming is performed, the quantity of suctioned ink is also cumulatively stored as a number of printed dots. By comparing the sum of these numbers with a number
15 representing the total number of dots which are printable from a full ink cartridge, it is possible to accurately display the residual quantity of ink in the ink cartridge. Furthermore, this effect can be achieved by means of ink jet printer software without increasing cost of an ink cartridge.

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We claim:

1. An ink residual quantity sensor of an ink jet printer provided with a head having a head nozzle to eject ink for printing, an ink cartridge containing ink and a priming means to suction ink while applying pressure to the head nozzle,
5 said residual quantity sensor characteristically comprising:

a printable dot number storage means to store a number of printable dots corresponding to the full volume capacity of said ink cartridge;

a printed dot number storage means to store a number of dots actually printed by said head;

- 10 a storage control means to cause quantity of the ink which has been suctioned to be cumulatively stored as a number of printed dots in said printed dot number storage means for each action of said priming means; and

an ink residue detection means which computes the residual quantity of ink based on said numbers of printable dots and printed dots.

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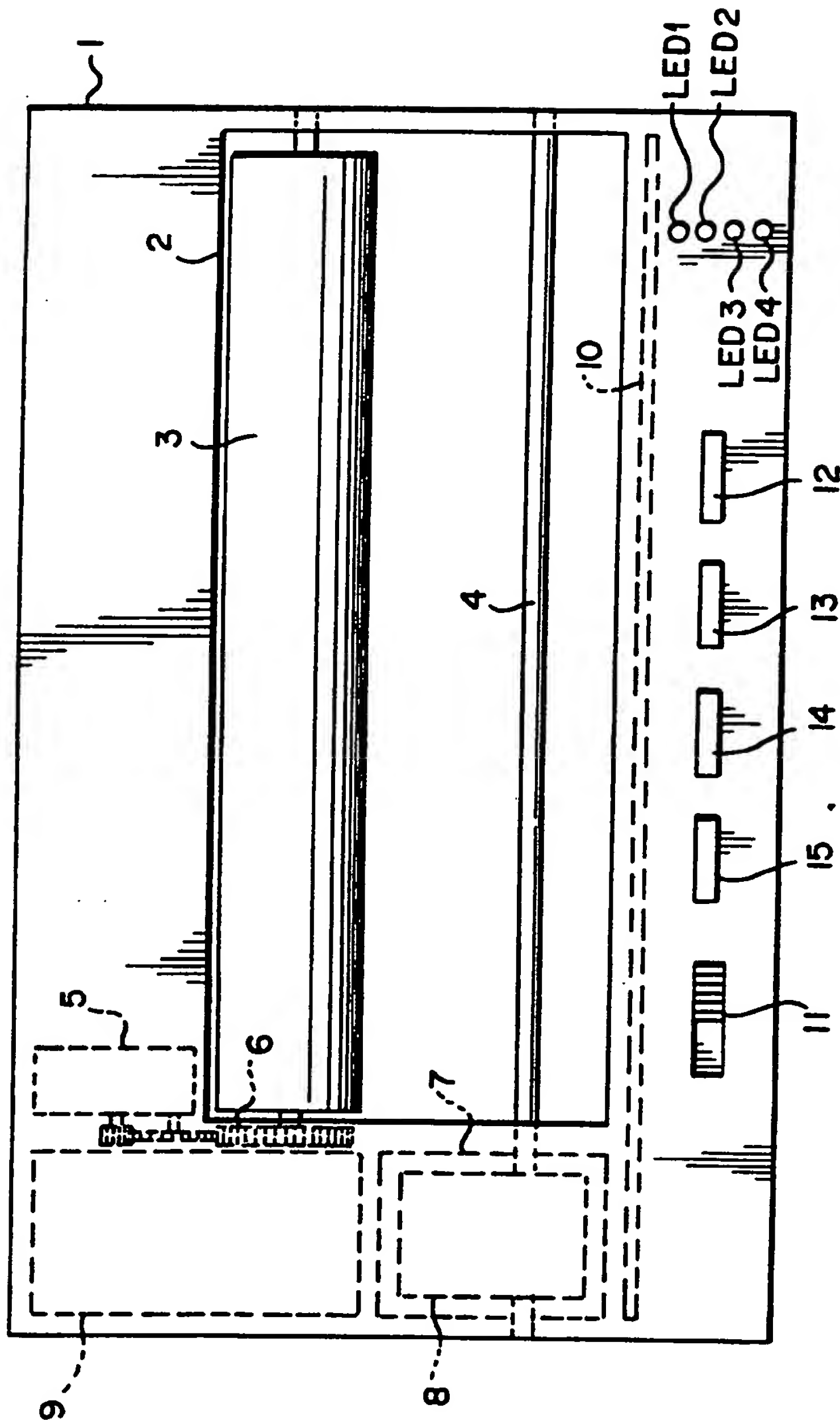


FIG. 1

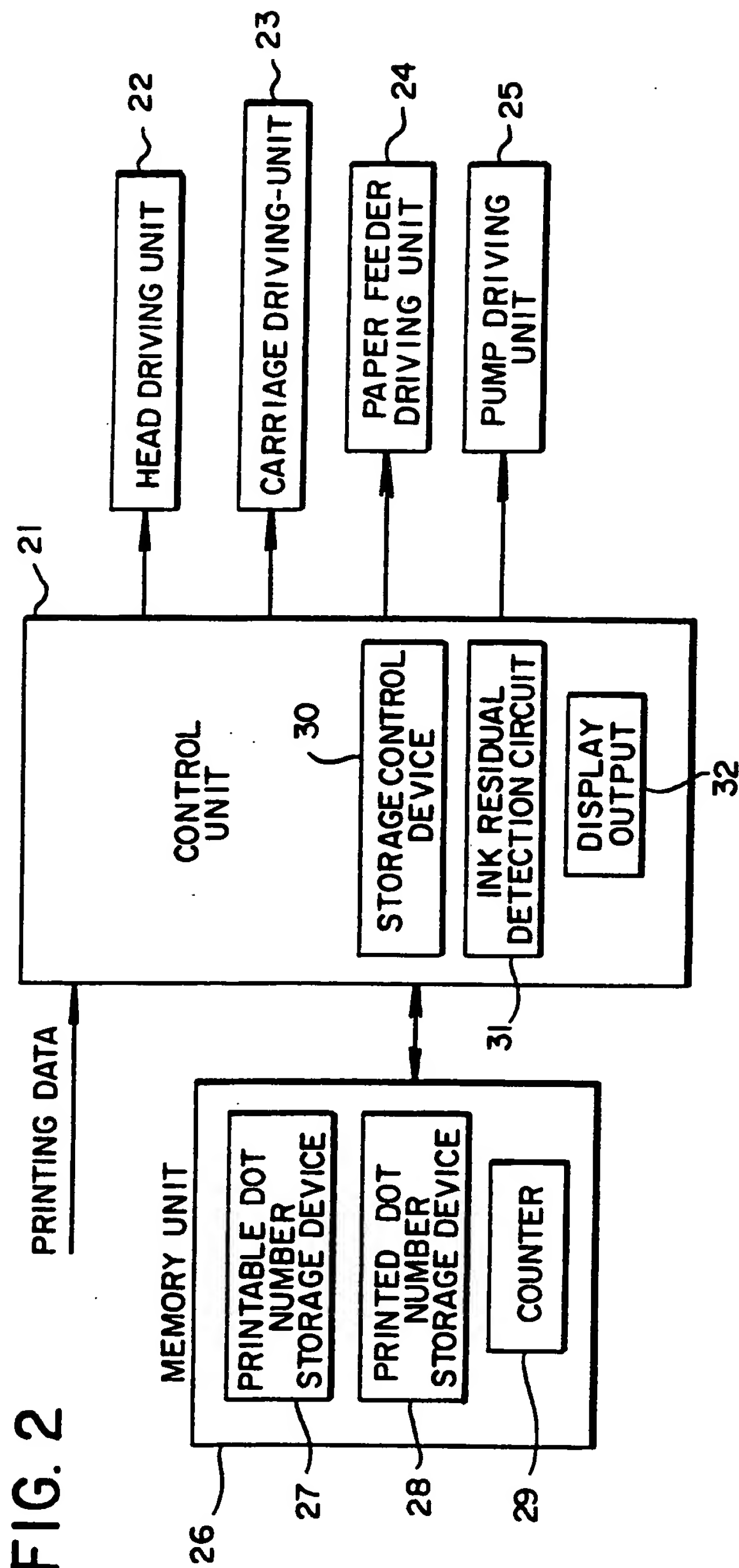


FIG. 4

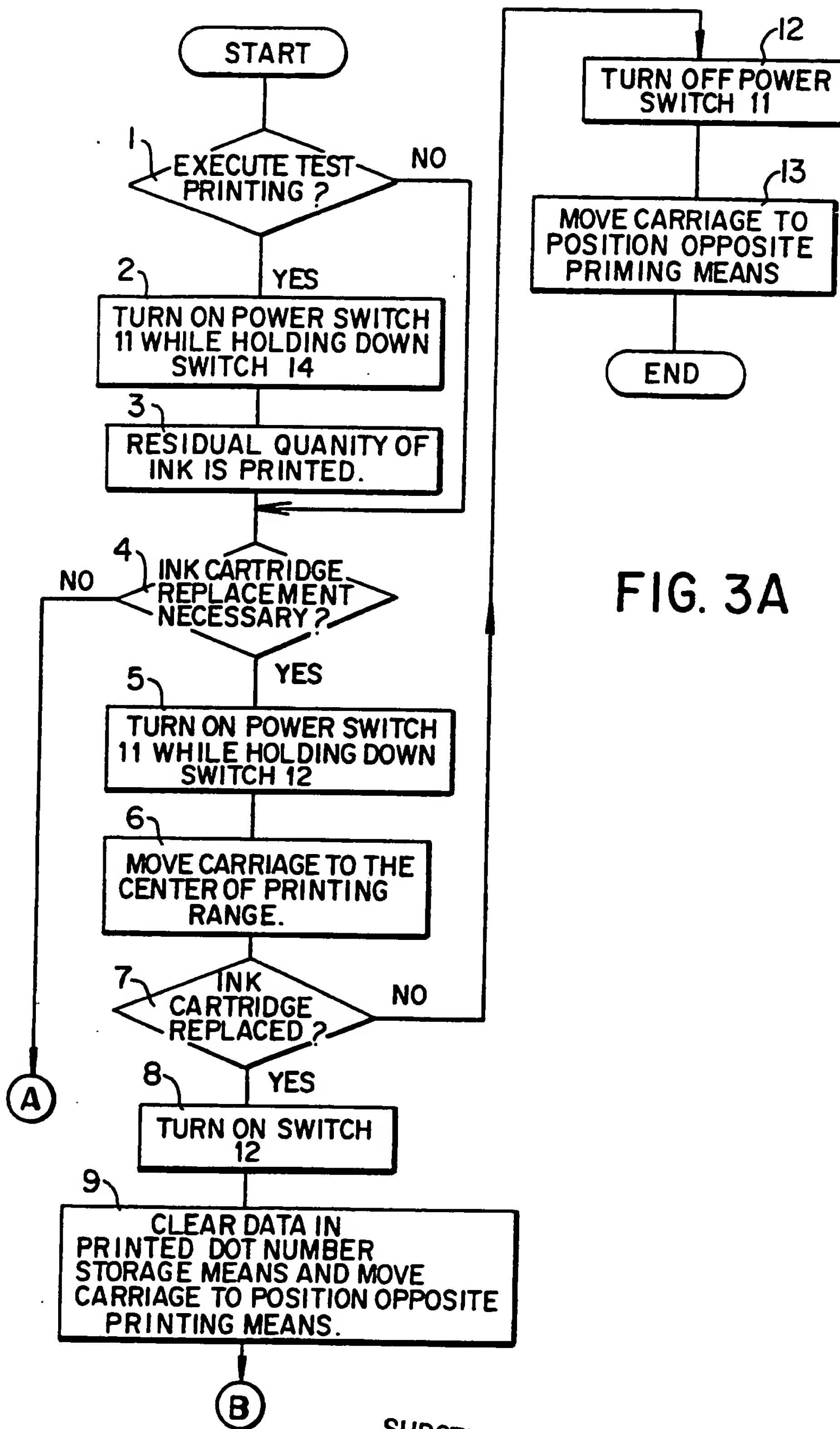
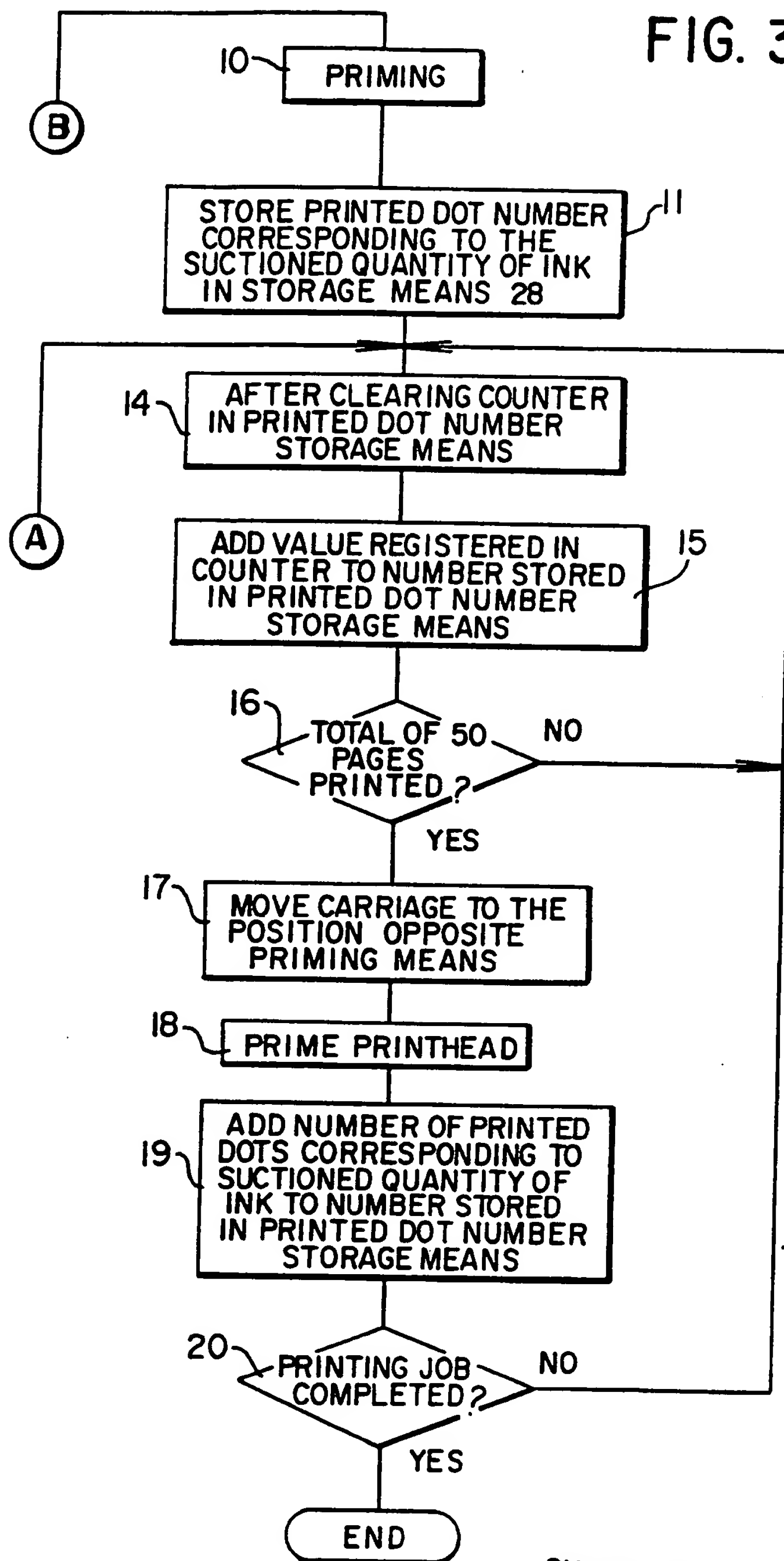


FIG. 3A

FIG. 3B



SUBSTITUTE SHEET

INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 92/03074

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) * According to International Patent Classification (IPC) or to both National Classification and IPC IPC ⁵ : B 41 J 2/175											
II. FIELDS SEARCHED <div style="text-align: center; border-top: 1px solid black; border-bottom: 1px solid black; margin: 5px 0;">Minimum Documentation Searched ⁷</div> <table style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 30%; border-bottom: 1px solid black;">Classification System</th> <th style="width: 70%; border-bottom: 1px solid black;">Classification Symbols</th> </tr> <tr> <td style="border-right: 1px solid black; padding: 5px;">IPC⁵</td> <td style="padding: 5px;">B 41 J, G 01 F</td> </tr> </table> <div style="text-align: center; border-top: 1px solid black; border-bottom: 1px solid black; margin: 5px 0;">Documentation Searched other than Minimum Documentation to the extent that such Documents are included in the Fields Searched ⁸</div>			Classification System	Classification Symbols	IPC ⁵	B 41 J, G 01 F					
Classification System	Classification Symbols										
IPC ⁵	B 41 J, G 01 F										
III. DOCUMENTS CONSIDERED TO BE RELEVANT⁹ <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 10%; padding: 5px;">Category ¹⁰</th> <th style="width: 60%; padding: 5px;">Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²</th> <th style="width: 30%; padding: 5px;">Relevant to Claim No. ¹³</th> </tr> </thead> <tbody> <tr> <td style="text-align: center; vertical-align: top; padding: 5px;">A</td> <td style="padding: 5px;"> WO, A1, 90/00 974 (SIEMENS AKTIENGESELLSCHAFT) 08 February 1990 (08.02.90), see fig. 1; abstract; page 8, lines 1-15; page 10, lines 6-8. </td> <td style="text-align: center; vertical-align: top; padding: 5px;">1</td> </tr> <tr> <td style="text-align: center; vertical-align: top; padding: 5px;">A</td> <td style="padding: 5px;"> EP, B1, 0 086 061 (IMPERIAL CHEMICAL INDUSTRIES PLC) 24 June 1987 (24.06.87), see claims 1,6. </td> <td style="text-align: center; vertical-align: top; padding: 5px;">1</td> </tr> </tbody> </table>			Category ¹⁰	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³	A	WO, A1, 90/00 974 (SIEMENS AKTIENGESELLSCHAFT) 08 February 1990 (08.02.90), see fig. 1; abstract; page 8, lines 1-15; page 10, lines 6-8.	1	A	EP, B1, 0 086 061 (IMPERIAL CHEMICAL INDUSTRIES PLC) 24 June 1987 (24.06.87), see claims 1,6.	1
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<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p>* Special categories of cited documents: ¹⁴</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="width: 45%;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"Z" document member of the same patent family</p> </div> </div>											
IV. CERTIFICATION <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%; border-bottom: 1px solid black; padding: 5px;"> Date of the Actual Completion of the International Search <div style="text-align: center; font-weight: bold;">12 August 1992</div> </td> <td style="width: 50%; border-bottom: 1px solid black; padding: 5px;"> Date of Mailing of this International Search Report <div style="text-align: center; font-weight: bold;">04 SEP 1992</div> </td> </tr> <tr> <td style="border-bottom: 1px solid black; padding: 5px;"> International Searching Authority <div style="text-align: center; font-weight: bold;">EUROPEAN PATENT OFFICE</div> </td> <td style="border-bottom: 1px solid black; padding: 5px;"> Signature of Authorized Officer <div style="text-align: center; font-weight: bold;">MEISTERLE e.h.</div> </td> </tr> </table>			Date of the Actual Completion of the International Search <div style="text-align: center; font-weight: bold;">12 August 1992</div>	Date of Mailing of this International Search Report <div style="text-align: center; font-weight: bold;">04 SEP 1992</div>	International Searching Authority <div style="text-align: center; font-weight: bold;">EUROPEAN PATENT OFFICE</div>	Signature of Authorized Officer <div style="text-align: center; font-weight: bold;">MEISTERLE e.h.</div>					
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ANHANG

zum internationalen Recherchen-
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ANNEX

to the International Search
Report to the International Patent
Application No.

A. JNEXE

au rapport de recherche inter-
national relatif à la demande de brevet
international n°

PCT/US 92/03074 SAE 59897

In diesem Anhang sind die Mitglieder
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WD A1	9000974	08-02-90	EP A1 433280 JP T2 4500482	26-06-91 30-01-92
EP B1	86061	24-06-87	AT E 27944 AU A1 10841/83 AU B2 569245 BR A 8300458 BR A 8300558 CA A1 1190629 CA A1 1199419 CA A1 1217547 DE C0 3372202 DK A0 488/83 DK A 488/83 DK B 161958 DK C 161958 EP A1 86030 EP A1 86031 EP A1 86061 EP A1 86075 ES A1 519522 ES A5 519522 ES A1 8500769 GB A0 8302588 GB A0 8302674 GB A1 2114412 GB A1 2115317 GB B2 2115317 GB B2 2114412 HU B 189220 IE B 54378 IL A0 67722 JP A2 58146465 JP A2 58150457 JP A2 58193255 JP A2 58193755 JP B4 4031939 MX A 158371 NZ A 203170 US A 4553702 US A 4629164 ZA A 8300535 AT E 32866 AU A1 10342/83 CA A1 1190630 DE C0 3375901 DK A0 440/83 DK A 440/83 EP A1 86029 EP B1 86029 ES A1 519525 ES A5 519525 ES A1 531175 ES A1 8500091 ES A5 531175 ES A1 8502353 GB A0 8300094 GB A1 2115316 HU A2 42914 HU B 194681 IE B 54377 IL A0 67704 JP A2 58146464 MX A 158668	15-07-87 11-08-83 28-01-88 01-11-83 08-11-83 16-07-85 14-01-86 03-02-87 30-07-87 31-01-83 06-08-83 02-09-91 10-02-92 17-08-83 17-08-83 17-08-83 17-08-83 01-11-84 30-11-84 01-02-85 02-03-83 02-03-83 24-08-83 07-09-83 10-07-85 05-02-86 30-06-86 13-09-89 15-05-83 01-09-83 07-09-83 10-11-83 11-11-83 27-05-92 27-01-89 09-05-86 19-11-85 16-12-86 30-11-83 15-03-88 11-08-83 16-07-85 14-04-88 31-01-83 06-08-83 17-08-83 09-03-88 01-10-84 31-10-84 01-01-85 01-01-85 01-02-85 01-04-85 09-02-83 07-09-83 28-09-87 28-03-88 13-09-89 15-05-83 01-09-83 24-02-89

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DK	A	4108/86	28-08-86
DK	A0	4108/86	28-08-86
EG	A	15799	30-03-87
EG	A	15799	30-03-88
ES	A1	509574	16-12-82
ES	A5	509574	14-01-83
ES	A1	8301581	01-04-83
HU	B	187640	28-02-86
IE	B	52901	13-04-88
IL	A0	64980	30-04-84
IL	A1	64980	30-06-85
JP	A2	57159567	01-10-82
JP	B4	3022221	26-03-91
MX	A	158890	29-03-89
NZ	A	199580	13-09-85
SU	A3	1099829	23-06-84
ZA	A	8200563	29-12-82
ZW	A	17/82	31-08-83

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